

CLAIMS

1. A process for producing isoprenoid compounds comprising integrating DNA into a vector wherein the DNA contains one or more DNA selected from the following (a), (b), (c), (d), (e) and (f):

- (a) a DNA encoding a protein having activity to catalyze a reaction to produce 1-deoxy-D-xylulose 5-phosphate from pyruvic acid and glyceraldehyde 3-phosphate,
- (b) a DNA encoding farnesyl pyrophosphate synthase,
- (c) a DNA encoding a protein that has an amino acid sequence of SEQ ID NO:3, or a protein that has an amino acid sequence wherein one to several amino acid residues are deleted, substituted or added in the amino acid sequence of SEQ ID NO: 3 and has activity to improve efficiency in the biosynthesis of isoprenoid compounds,
- (d) a DNA encoding a protein that has an amino acid sequence of SEQ ID NO:4, or a protein that has an amino acid sequence wherein one to several amino acid residues are deleted, substituted or added in the amino acid sequence of SEQ ID NO: 4 and has activity to improve efficiency in the biosynthesis of isoprenoid compounds,
- (e) a DNA encoding a protein having activity to catalyze a reaction to produce 2-C-methyl-D-erythritol 4-phosphate from 1-deoxy-D-xylulose 5-phosphate, and
- (f) a DNA encoding a protein that can hybridize under stringent conditions with DNA selected from (a), (b), (c), (d) and (e), and has activity substantially identical with that of the protein encoded by the selected DNA;

introducing the resultant recombinant DNA into a host cell derived from prokaryotes, culturing the obtained transformant in a medium; allowing the transformant to produce and accumulate isoprenoid compounds in the culture; and recovering the isoprenoid compounds from the culture.

2. The process according to claim 1, wherein the DNA encoding a protein having activity to catalyze a reaction to produce 1-deoxy-D-xylulose 5-phosphate from pyruvic acid and glyceraldehyde 3-phosphate is a DNA encoding a protein that has an amino acid sequence of any one of SEQ ID NOS: 1, 26 and 28, or a DNA encoding a protein that has an amino acid sequence wherein one to several amino acid residues are deleted, substituted or added in the amino acid sequence of SEQ ID NO: 1, 26 or 28 and has activity to catalyze a reaction to produce 1-deoxy-D-xylulose 5-phosphate from pyruvic acid and

glyceraldehyde 3-phosphate.

3. The process according to claim 1 or 2, wherein the DNA has a nucleotide sequence of any one of SEQ ID NOS: 6, 27 and 29.

4. The process according to claim 1, wherein a DNA encoding farnesyl pyrophosphate synthase is a DNA encoding a protein that has an amino acid sequence of SEQ ID NO:2, or a DNA encoding farnesyl pyrophosphate synthase that has an amino acid sequence wherein one to several amino acid residues are deleted, substituted or added in the amino acid sequence of SEQ ID NO: 2.

5. The process according to claim 1 or 4, wherein the DNA has a nucleotide sequence of SEQ ID NO:7.

6. The process according to claim 1, wherein the DNA encoding a protein having activity to catalyze a reaction to produce 2-C-methyl-D-erythritol 4-phosphate from 1-deoxy-D-xylulose 5-phosphate is a DNA encoding a protein that has an amino acid sequence of SEQ ID NO:5 or 30, or a DNA encoding a protein that has an amino acid sequence wherein one to several amino acid residues are deleted, substituted or added in the amino acid sequence of SEQ ID NO: 5 or 30 and has activity to catalyze a reaction to produce 2-C-methyl-D-erythritol 4-phosphate from 1-deoxy-D-xylulose 5-phosphate.

7. The process according to claim 1 or 6, wherein the DNA has a nucleotide sequence of SEQ ID NO:10 or 31.

8. The process according to claim 1, wherein the DNA has a nucleotide sequence of SEQ ID NO:8 or 9.

9. The process according to claim 1, wherein the isoprenoid compound is one selected from ubiquinone, vitamin K₂ and carotenoids.

10. A protein having activity to improve efficiency in the biosynthesis of isoprenoid compounds and selected from the following (a), (b) and (c):

(a) a protein having an amino acid sequence of SEQ ID NO:3, or a protein having an amino acid sequence wherein one to several amino acid residues are deleted, substituted or added in the amino acid sequence of SEQ ID NO: 3,

(b) a protein having an amino acid sequence of SEQ ID NO:4, or a protein having an amino acid sequence wherein one to several amino acid residues are deleted, substituted or added in the amino acid sequence of SEQ ID NO: 4, and

(c) a protein having an amino acid sequence of SEQ ID NO:5, or a protein having an amino acid sequence wherein one to several amino acid residues are deleted, substituted or added in the amino acid sequence of SEQ ID NO:5.

11. A process for producing a protein having activity to improve efficiency in the biosynthesis of isoprenoid compounds comprising integrating DNA encoding the protein of claim 10 into a vector, introducing the resultant recombinant DNA into a host cell, culturing the obtained transformant in a medium, allowing the transformant to produce and accumulate said protein in the culture, and recovering said protein from the culture.

12. The process according to claim 1 or 11, wherein the transformant is a microorganism belonging to the genus *Escherichia*, *Rhodobacter* or *Erwinia*.

13. A DNA encoding a protein having activity to improve efficiency in the biosynthesis of isoprenoid compounds and described in any one of the following (a) to (g):

- (a) a DNA encoding a protein having an amino acid sequence of SEQ ID NO:3,
- (b) a DNA encoding a protein having an amino acid sequence of SEQ ID NO:4,
- (c) a DNA encoding a protein having an amino acid sequence of SEQ ID NO:5,
- (d) a DNA having a nucleotide sequence of SEQ ID NO:8,
- (e) a DNA having a nucleotide sequence of SEQ ID NO:9,
- (f) a DNA having a nucleotide sequence of SEQ ID NO:10, and
- (g) a DNA which can hybridize with any one of DNA of (a) to (f) under stringent conditions.

14. A method for screening a substance having antibiotic activity comprising screening a substance that inhibits the reaction of a protein having activity of an enzyme selected from those present on the non-mevalonate pathway in which 1-deoxy-D-xylulose 5-phosphate biosynthesized from pyruvic acid and glyceraldehyde 3-phosphate is converted to 2-C-methyl-D-erythritol 4-phosphate from which isopentenyl pyrophosphate is biosynthesized.

15. A method for screening a substance having weeding activity comprising screening a substance that inhibits the reaction of a protein having activity of an enzyme selected from those present on the non-mevalonate pathway in which 1-deoxy-D-xylulose 5-phosphate biosynthesized from pyruvic acid and glyceraldehyde 3-phosphate is converted to 2-C-methyl-D-erythritol 4-phosphate from which isopentenyl pyrophosphate is biosynthesized.

16. The screening method according to claim 14 or 15, wherein the protein is a protein described in the following (a) or (b):

- (a) a protein having activity to catalyze a reaction to produce 1-deoxy-D-xylulose 5-phosphate from pyruvic acid and glyceraldehyde 3-phosphate, or
- (b) a protein having activity to catalyze a reaction to produce 2-C-methyl-D-erythritol 4-phosphate from 1-deoxy-D-xylulose 5-phosphate.

17. The screening method according to claim 16, wherein the protein that catalyzes a reaction to produce 1-deoxy-D-xylulose 5-phosphate from pyruvic acid and glyceraldehyde 3-phosphate is a protein that has an amino acid sequence of SEQ ID NO: 1, or a protein that has an amino acid sequence wherein one to several amino acid residues are deleted, substituted or added in the amino acid sequence of SEQ ID NO: 1 and has activity to catalyze a reaction to produce 1-deoxy-D-xylulose 5-phosphate from pyruvic acid and glyceraldehyde 3-phosphate.

18. The screening method according to claim 16, wherein the protein having activity to catalyze a reaction to produce 2-C-methyl-D-erythritol 4-phosphate from 1-deoxy-D-xylulose 5-phosphate is a protein that has an amino acid sequence of SEQ ID NO: 5, or a protein that has an amino acid sequence wherein one to several amino acid residues are deleted, substituted or added in the amino acid sequence of SEQ ID NO: 5 and has activity to catalyze a reaction to produce 2-C-methyl-D-erythritol 4-phosphate from 1-deoxy-D-xylulose 5-phosphate.

19. A substance having antibiotic activity, which is obtained by the screening method according to claim 14.

20. A substance having weeding activity, which is obtained by the screening method according to claim 15.

21. An antibiotic agent comprising the substance of claim 19.

22. A herbicide comprising the substance of claim 20.